# Interconnectivity Infrastructure Group

# TIGER TEAM

*Participating organizations, presented in alphabetical order, who participated substantively and contributed to the analysis contained herein:*

ERICSSON

MOTOROLA SOLUTIONS

Alcatel·Lucent

Nokia Siemens Networks

HARRIS

ANDREWSEYBOLD

IPWireless

CYNERGYZE

*V11.1* June 4, 2012

***Carrier – Technical Validation***

verizonwireless

at&t

***Public Safety Sponsors:***

TEXAS DEPARTMENT OF PUBLIC SAFETY COMMUNICATIONS LAW ENFORCEMENT SUPPORT DIVISION

CHARLOTTE.

**Revision History**

V11 Version approved by participants for publication

# The Interconnectivity Infrastructure Group (IIG)

- IIG includes lead architects from eight organizations
- The team was originally established to determine best infrastructure interconnectivity solution for the Early Builders.
- Team reconvened to analyze impact of a suspension
- ***All members of the IIG team were involved in the development of this material.***

Executive Sponsors

**Bill Schrier** – City of Seattle
**Todd Early** – State of Texas
**Jim Bogner** – State of Iowa

IIG Tiger Team

**Alcatel-Lucent** – Wim Brouwer
**Andrew Seybold, Inc** – Andy Seybold
**City of Charlotte** – Steve Koman
**Cynergyze/TX** – Cynthia Wenzel Cole
**Ericsson** – Patrik Ringqvist
**Harris** – Reid Johnson
**IPWireless** – Keith Sinclair
**Motorola Solutions (MSI)** – Gino Scribano
**Nokia-Siemens Networks** – Brian Kassa
**State of Texas** – Mike Barney

IIG Technical/Carrier Validation

**AT&T** – Stacey Black
**Verizon Wireless** – David Anderson

# IIG Tiger Team Assignments

- Examine the risks of creating “stranded” LTE equipment investments;
- Determine the implications of multiple vendor environments;
  - Focus on testing complexity and deployment strategies which reduces complexity
- Establish the value of allowing projects to continue, including:
  - Harvesting the lessons learned from those projects,
    - Examine ways early projects can provide benefits and reduce risk of future rework
    - Examine scenarios in which Early Builders have already purchased equipment
- Support “FirstNet Phase One” Proposal

# Conclusions

***The commercial carriers have remained neutral and did not weigh in on these conclusions.***

- The current governing entities should be assured Early Builders will support and abide by FCC and FirstNet directives.

- It will be better for FirstNet to use Early Deployments to find problems early, when they are small/regional rather than later when they are larger or become nationwide.
  - Suspending early build-outs *increases* risks for FirstNet
  - Nationwide network build-outs rely heavily upon effective Pilot programs

- Enabling Early Builders to deploy in controlled “FirstNet Phase One” pilot programs lowers risk for FirstNet.

# Conclusions, cont'd

***The commercial carriers have remained neutral and did not weigh in on these conclusions.***

- The potential cost of stranding some LTE equipment is relatively low compared to total PS LTE deployment costs.

- Complexity of testing can be managed using well-known industry Best Practices and can be minimized by "equipment grouping" within the network.

- Multi-Vendor Interoperability over standards-based interfaces is being successfully managed all over the world.
  - Implications of fewer vendors and a suspension of deployments risks stifling both innovation and competition.
    - Vendors may reduce investment in PS-centric capabilities
  - Ultimately driving up costs and lowering value to PS.

# Lowering the Risk of Stranded Investments

# Factors Which Lower Risk of Stranded LTE Eqt

- Use of open, LTE 3GPP standards promotes interoperability across the entire ecosystem, thus reducing the risk of stranding equipment.
- Interoperability Showings articulate commitment to comply with specific FCC and 3GPP requirements in intricate detail.
- All of the major vendors and Early Builders have agreed on an interconnect model which:
  - Uses well-established principles and practices used by commercial carriers
  - Can easily be integrated or adapted to FirstNet
- The Numbering Scheme was developed by DHS-OEC in partnership with OAC, to ensure a smooth integration with FirstNet.

# Factors Which Lower Risk of Stranded LTE Eqt

- Hosted Core options present lower risk of stranded equipment cost being carried by public safety agencies.
- Ability to repurpose equipment. This flexibility might prevent a device from being scrapped all together.
  - Same component may be used by multiple EPC Elements
  - Same hardware may be used for multiple EPC elements, can be reconfigured and reused by FirstNet
    - Would have to be assessed on case by case basis.

# Factors Which Lower Risk of Stranded LTE Eqt

- Band 14 UEs and eNodeBs support both the 5+5 MHz waiver network spectrum as well as the 10+10 FirstNet Spectrum now available with the addition of the D Block
  - No need to reconfigure devices, they will support both.
  - Base stations can be reconfigured to support 10+10 MHz, it is just a parameter change
    - Note requires downtime for cell during re-configuration
  - No changes in EPC (core) needed for this re-configuration.
  - Some devices may require additional FCC type approvals

# Assumptions, Introduction to Scenarios

- All design options constitute “one, single network” as required by the statute.
  - The design is established with the single, Common PLMN ID
  - Single network can be comprised of multiple Sub-Networks and still be part of one, single network
    - We are not proposing a “Network of Networks” solution
- Scenarios have been developed using real network examples but illustrate generic concepts that can be applied to any system.
  - For examples, we used four “Early Builders” systems, City of Charlotte, State of Texas, State of Mississippi and Adams County, CO
- Scenarios show how early networks could migrate to various FirstNet design options.

# LTE Equipment Cost Model

- **Typical Large network deployments allocate costs as follow**
  - **RAN Build-out – 80%**
    - Equipment 10% Backhaul 20%
    - Site acquisition, civil work, hardening, installation, etc.– 70%
  - **Core Build-out – 20%**
    - Equipment – 50%
    - Services – 50%

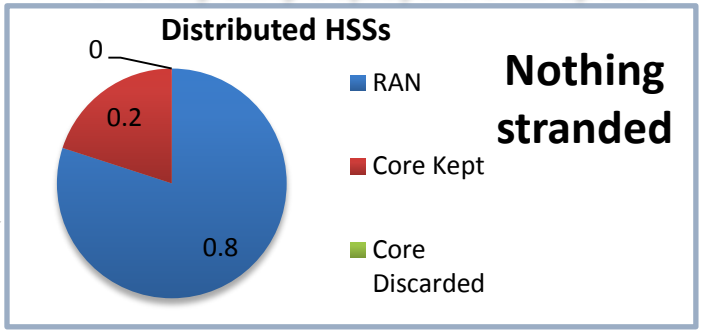
- **Each primary EPC elements (HSS, PCRF, MME, S&P GW and Network Management) attracts approximately 20% of equipment costs**

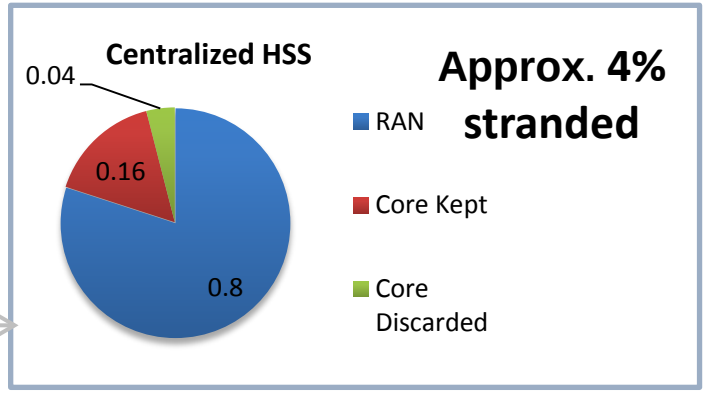
- **FirstNet Single Network Design examples, some of the options analyzed:**
  - **Distributed HSSs**
    - Keep all equipment
  - **Centralized HSSs**
    - Keep Network Management, S&P GW, RAN, PCRF and MME
    - Consolidate HSSs into centralized FirstNet Core

Caveats:

- These ratios are based on medium to large commercial network build outs.
- A 10% swing in the ratio results in a 2 cent change in the result

***For Every Early Deployer Dollar Spent***

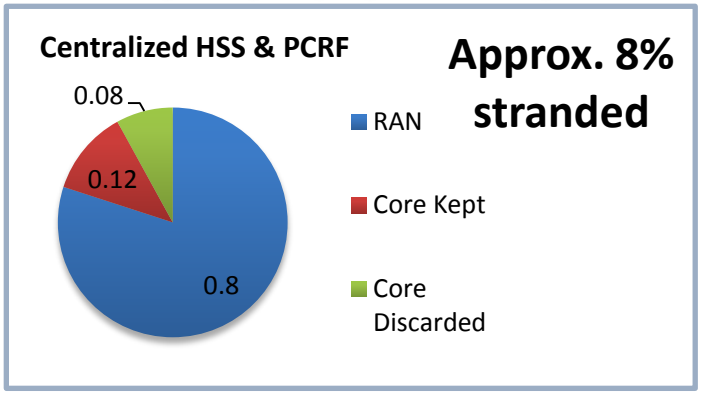


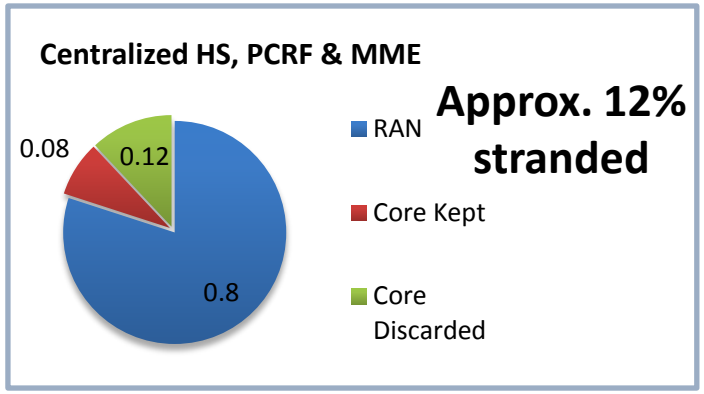
# LTE Equipment Cost Model

*For Every Early Deployer Dollar Spent*

- **FirstNet Single Network Design examples, some of the options analyzed :**
  - **Centralized HSSs + PCRFs**
    - Keep Network Management, S&P GW, MME and RAN
    - Consolidate HSS, PCRF into centralized FirstNet Core




  - **Centralized HSSs + PCRFs + MMEs**
    - Keep Network Management, S&P GW and RAN
    - Consolidate HSS, PCRF & MMEs into centralized FirstNet Core
    - MMEs could be taken over by FirstNet thus taking this scenario back to 8 cents stranded

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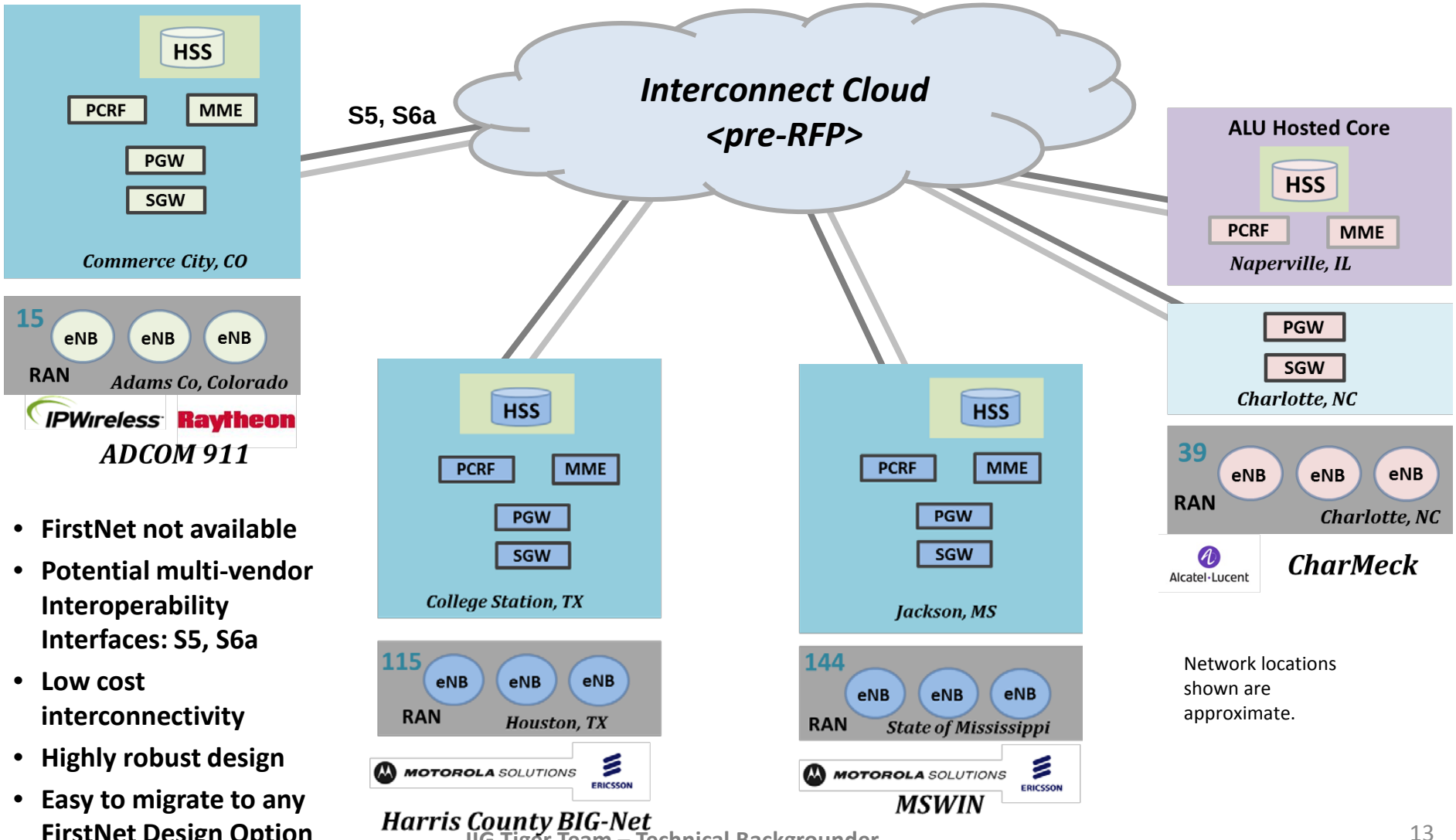
# Scenario 1

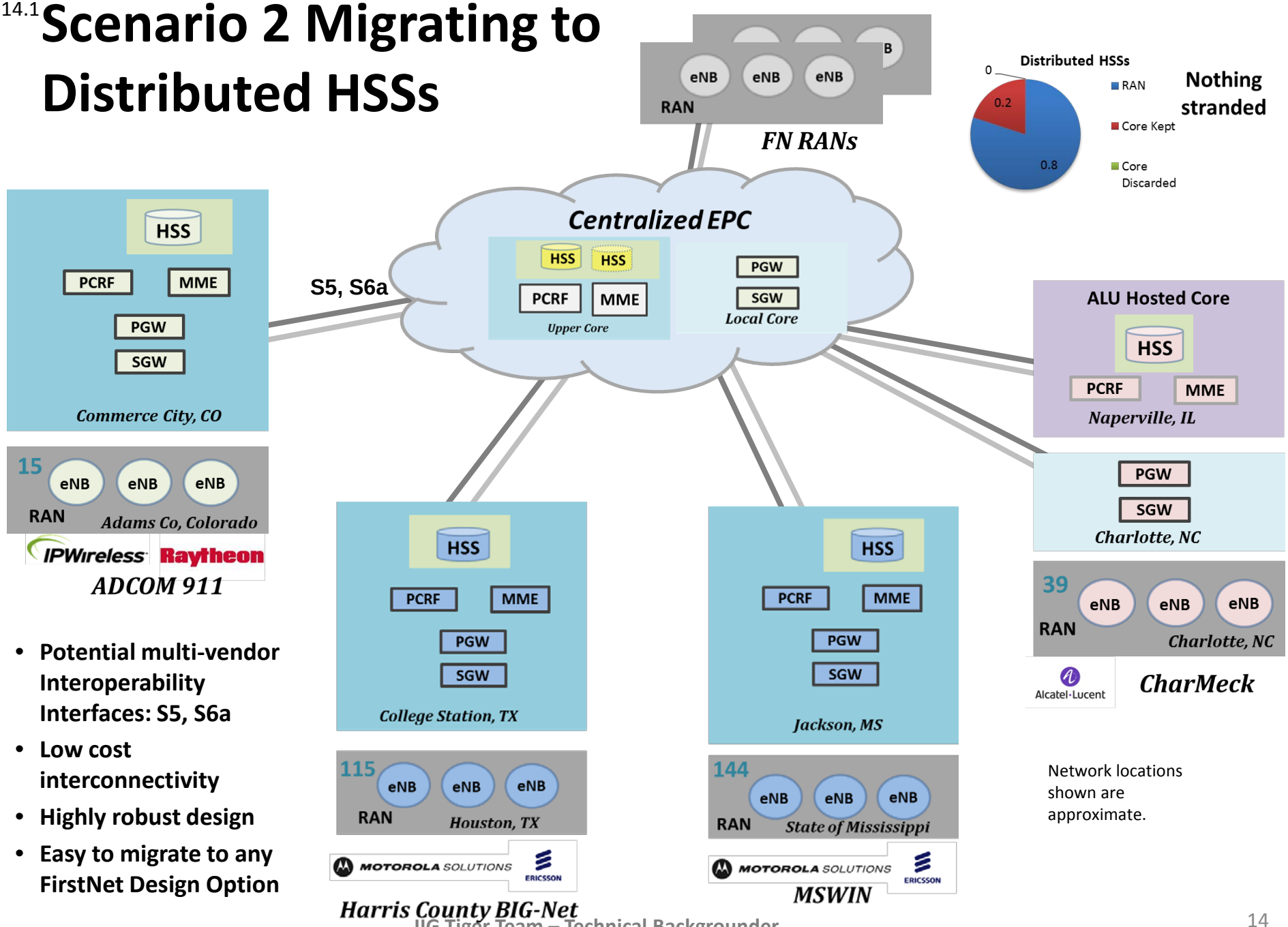
## *Distributed HSSs (pre FirstNet RFP)*




- FirstNet not available
- Potential multi-vendor Interoperability Interfaces: S5, S6a
- Low cost interconnectivity
- Highly robust design
- Easy to migrate to any FirstNet Design Option

Network locations shown are approximate.

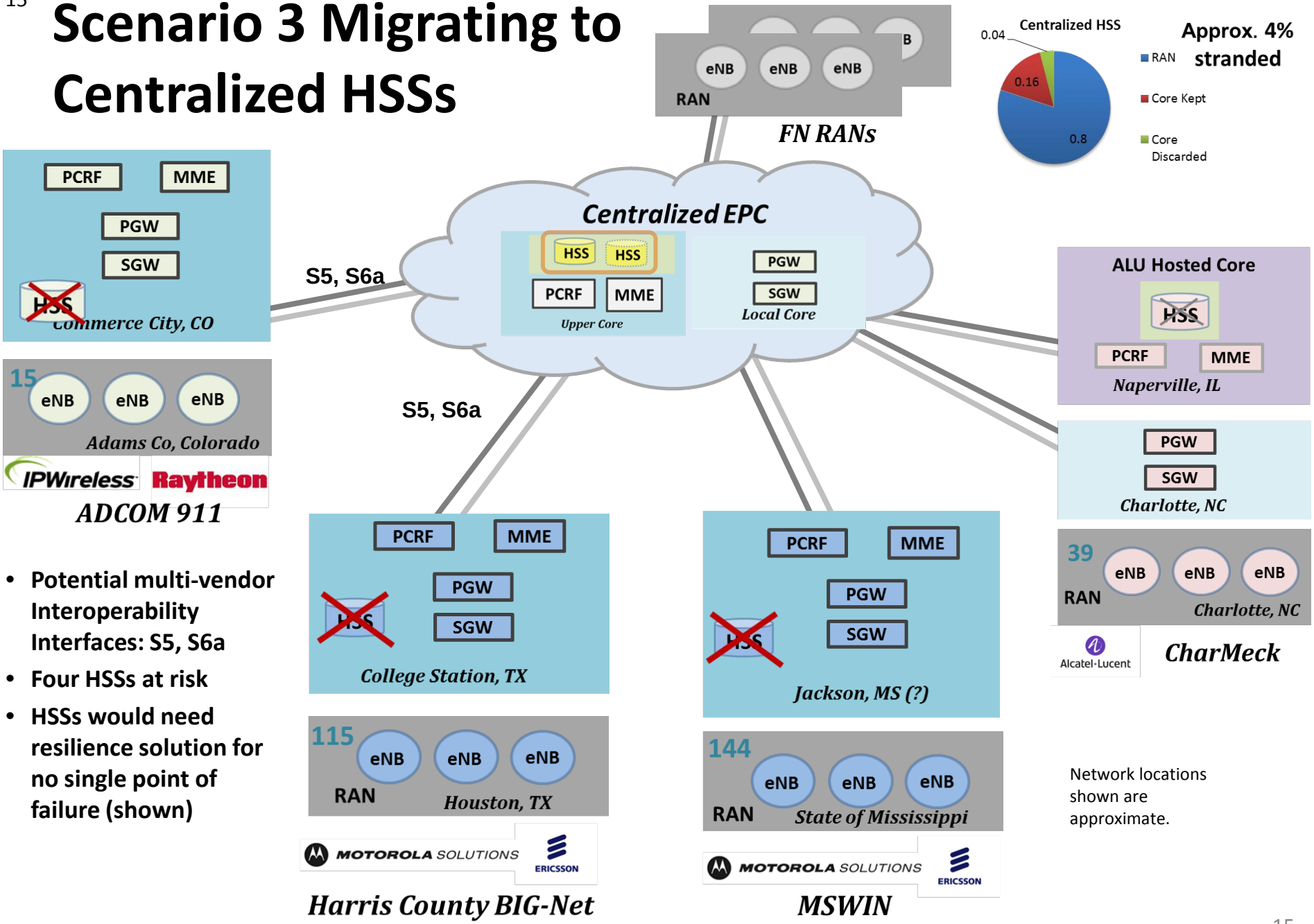
# Scenario 2 Migrating to Distributed HSSs




- Potential multi-vendor Interoperability Interfaces: S5, S6a
- Low cost interconnectivity
- Highly robust design
- Easy to migrate to any FirstNet Design Option

Network locations shown are approximate.

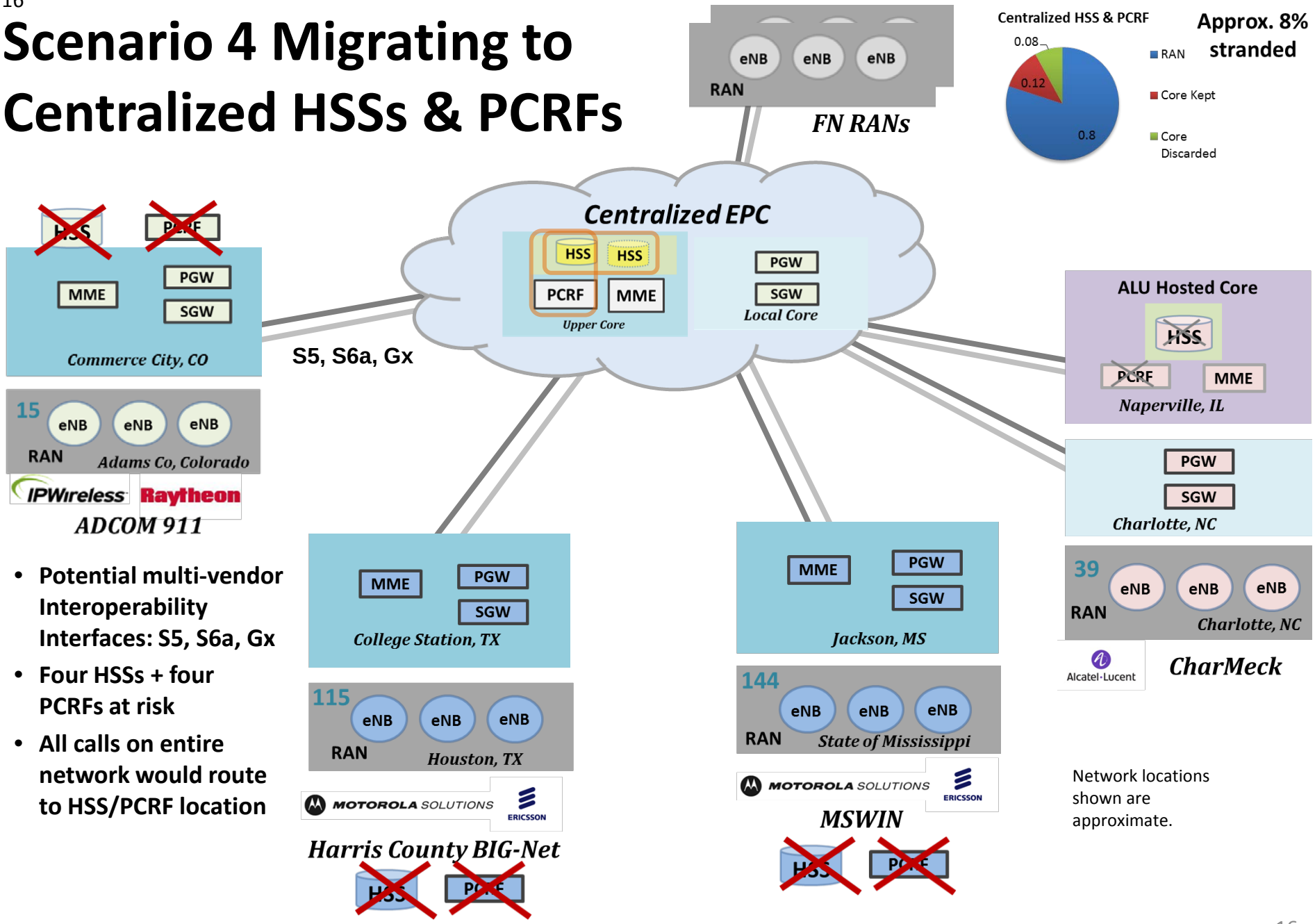
# Scenario 3 Migrating to Centralized HSSs




- Potential multi-vendor Interoperability Interfaces: S5, S6a
- Four HSSs at risk
- HSSs would need resilience solution for no single point of failure (shown)

Network locations shown are approximate.

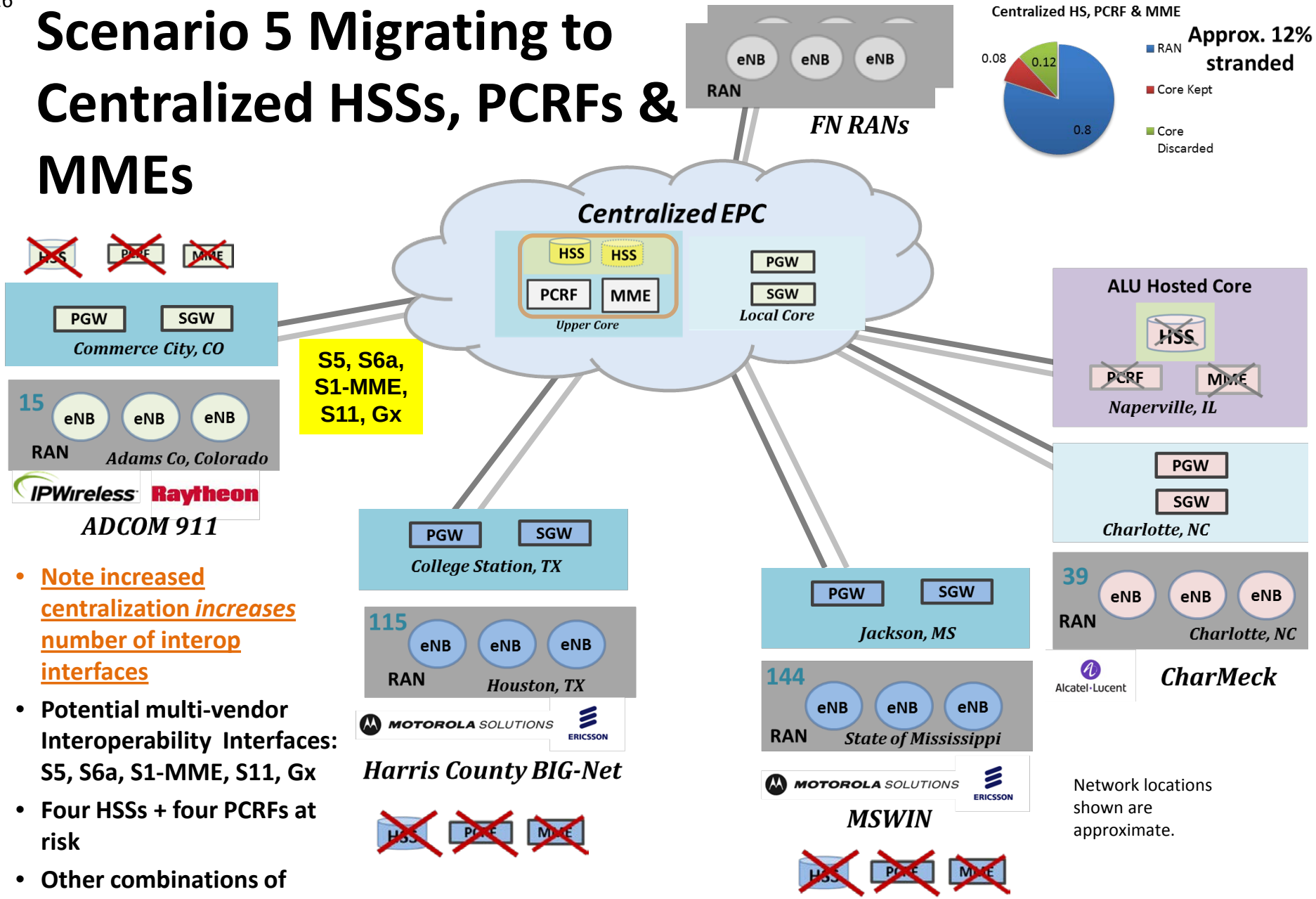
# Scenario 4 Migrating to Centralized HSSs & PCRFs




- Potential multi-vendor Interoperability Interfaces: S5, S6a, Gx
- Four HSSs + four PCRFs at risk
- All calls on entire network would route to HSS/PCRF location

Network locations shown are approximate.

# Scenario 5 Migrating to Centralized HSSs, PCRFs & MMEs




- Note increased centralization *increases* number of interop interfaces
- Potential multi-vendor Interoperability Interfaces: S5, S6a, S1-MME, S11, Gx
- Four HSSs + four PCRFs at risk
- Other combinations of equipment are possible

Network locations shown are approximate.

# FCC OBI Technical Paper No. 2 Cost Model[1]

- Estimated CAPEX cost of building network is $15.6B
- Approximate cost of EPC (core) equipment is $1B
- Worst case for stranded equipment is approximately 6% of nationwide CAPEX spend

- The OBI figures generally substantiate the IIG cost analysis, shown previously

[1] "*A Broadband Network Cost Model*," OBI Technical Paper No. 2, FCC, May 2010.

# Interoperability Status

# Interoperability & Interconnectivity

- Use of open 3GPP standards enables interoperability.
- With the filing of the Interoperability Showings, the manufacturers and agencies have provided detailed information regarding all commitments to FCC interoperability requirements.
- Commercial carriers typically employ multiple vendor equipment suppliers
  - Significant IOT has been and will continue to be done by commercial carriers
- Best Practices design requires only a small subset of standardized interfaces to be exposed between vendors.
  - How the network is designed is a much greater predictor of test loading and complexity than just how many vendors
- Use of interfaces which are more frequently used to interconnect different vendors' equipment, such as S6a, S5 and Gx, reduces risk overall by leveraging commercial successes.

# Deploying EPC Components into Vendor "Groupings" Reduces Complexity

- "Grouping" by vendors dramatically reduces complexity by exposing fewer interfaces, requiring less Interoperability Testing (IOT)
  - Commercial LTE carriers use this technique successfully
- Another technique is to mix vendors, but on a regional basis.
  - Commercial LTE carriers also use this technique successfully
- Using a different vendor for every component is unmanageable
  - Creates thousands of test cases
- Using a single vendor is also problematic, creating reliability problems, lack of competitiveness and potentially, driving up overall costs.
- *Many design scenarios are possible, examples next…*

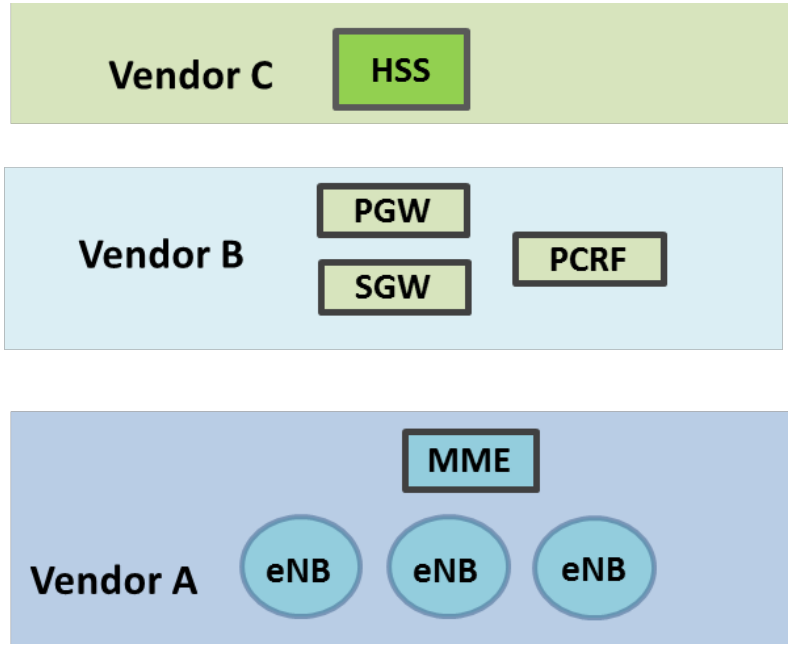
# Introduction to Vendor Groupings

***Purpose is to Show How Multiple Vendors Can Work Together Effectively***

***Many Combinations Possible***

***Fundamentally Defines Level of IOT Required***

*Example*



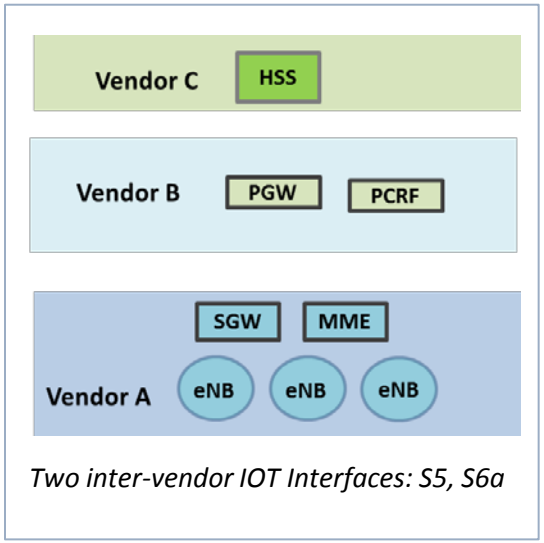

Vendor Colors and Labels DO NOT correspond to particular manufacturers!

Denotes designs in operational use today *

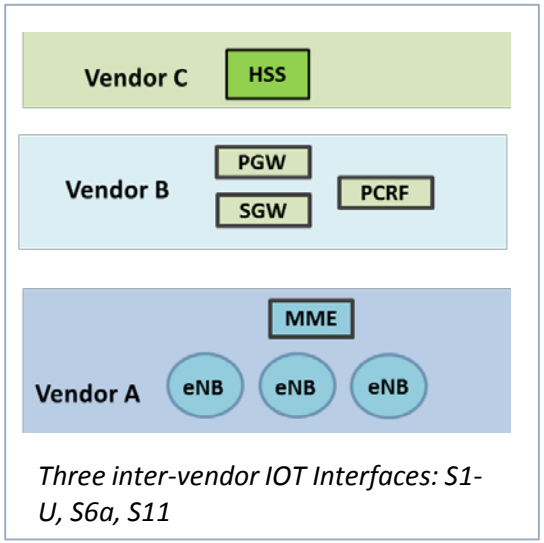
Color Vendor X blocks do NOT imply geographical or physical location.

Color Vendor X blocks do NOT imply ownership.

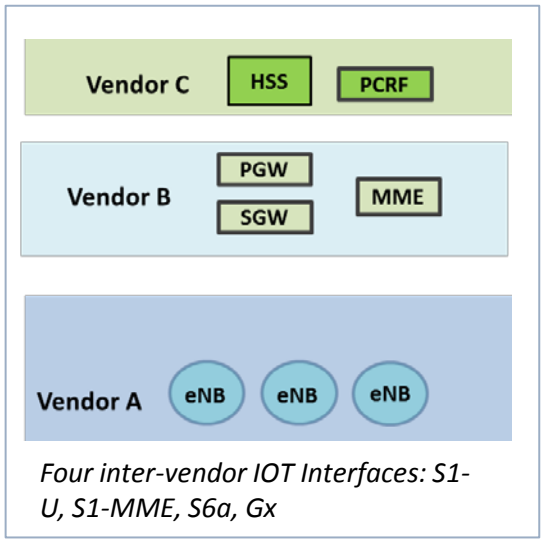
# Vendor "Grouping" Examples



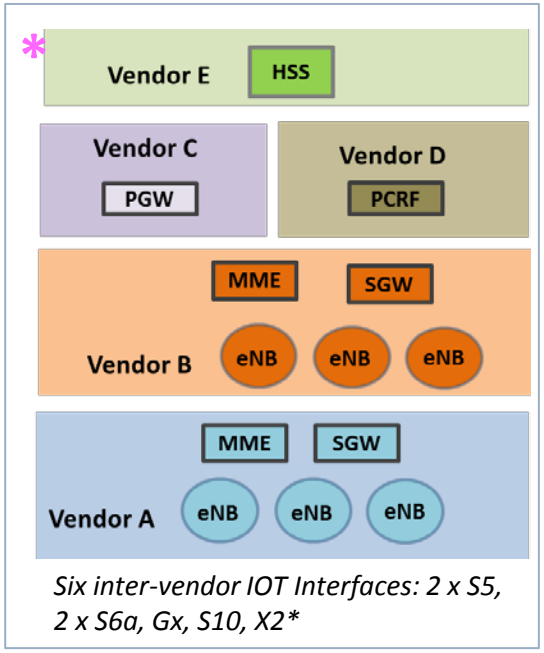

*Two inter-vendor IOT Interfaces: S5, S6a*



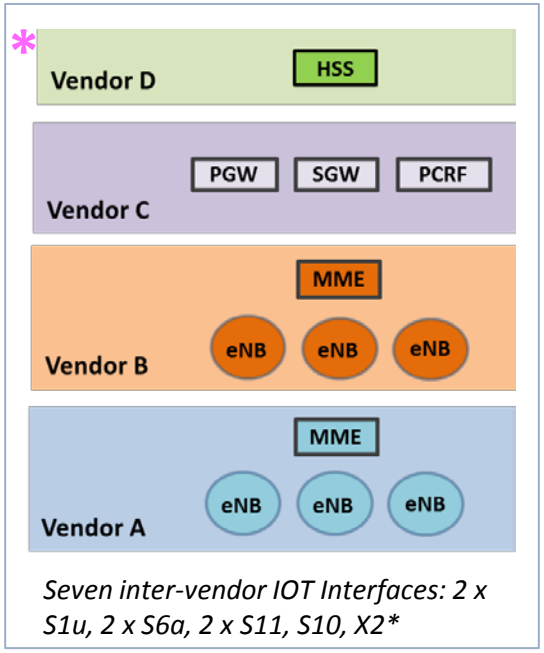

*Three inter-vendor IOT Interfaces: S1-U, S6a, S11*




*Four inter-vendor IOT Interfaces: S1-U, S1-MME, S6a, Gx*




*Six inter-vendor IOT Interfaces: 2 x S5, 2 x S6a, Gx, S10, X2**




*Seven inter-vendor IOT Interfaces: 2 x S1u, 2 x S6a, 2 x S11, S10, X2**

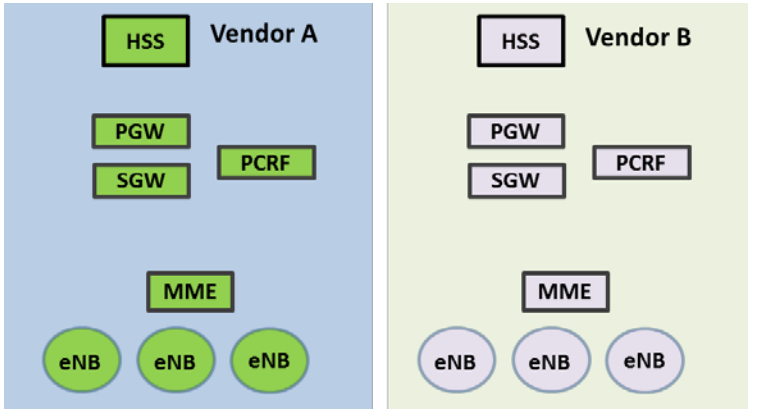
- **Examples show multiple ways to achieve manageable inter-vendor IOT and management scope**
- **Some being used today**
- **Complexity can be further reduced by "regionalizing" deployments (not shown)**

*2-vendor RAN*

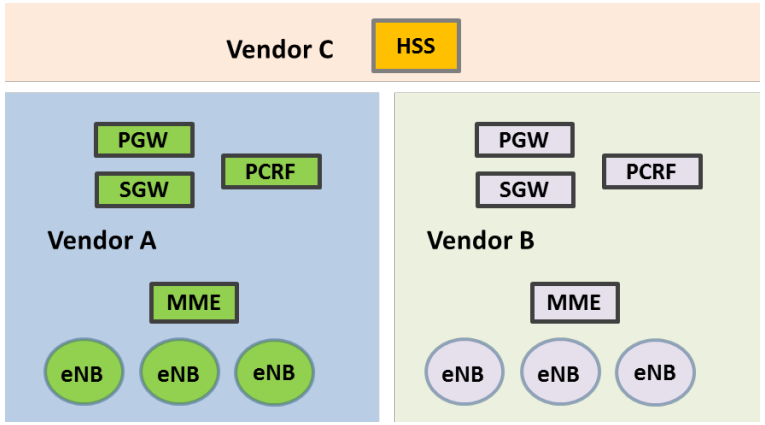
v6

*Inter-vendor X2 not yet implemented.

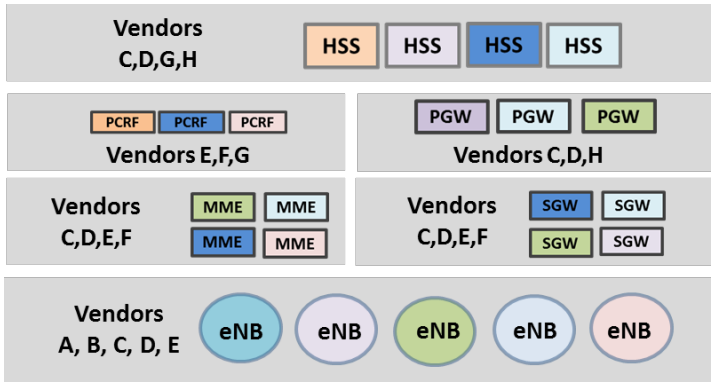
# Vendor "Grouping" Examples, cont'd



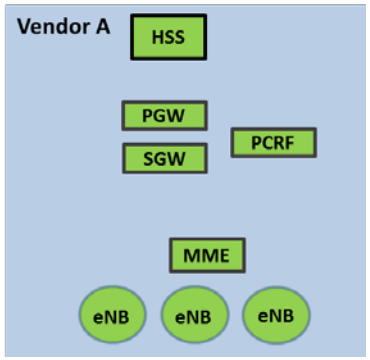

*Four inter-vendor IOT Interfaces: S5, S6a, Gx, X2*




*Five inter-vendor IOT Interfaces: S5, 2x S6a, Gx, X2*




*EXAMPLE OF AN EXTREME MIX - results in dozens of IOT Interfaces, thousands of tests =* ***NON-STARTER***




*Single Vendor , no competition =* ***NON-STARTER***

- **Above examples illustrate additional options**
- **Allowing an extreme mix of vendors, such as shown in example at left, creates an unmanageable environment and is a non-starter**
- **Single vendor eliminates competition and is a non starter**

# Advantages of Early Build-outs

# Advantages of Early Build-Outs

- Early Builders will reduce the cost of FirstNet deployment
- Deliver desperately needed PS LTE services sooner
- Maintain goodwill with early adopters, sponsors and public safety practitioners.
- Pilot programs accelerate learning and buy down risks

# Large Commercial Deployments Use Pilot Programs to Reduce Risk

- Mirrors the approach taken by national telecommunications carriers
  - e.g. Verizon created extensive pilot networks in Boston and Seattle before architecting and building out its nationwide network
  - e.g. AT&T created pilot in Dallas
- Inevitable flaws, bugs and problems are revealed in and contained by smaller, regional settings, reducing nationwide impact.
- For an efficient nationwide rollout, FirstNet will need to be deployed simultaneously, in multiple regions and in phases
  - Early Builders provide operational foundation and opportunity to learn earlier
  - Implementation lessons learned can be leveraged into better results in subsequent phases

# Potential Lessons Learned by Deploying "FirstNet Phase One"

- FirstNet architecture based on city, county and statewide environments reflected by the diversity of the Phase One jurisdictions.
- Ability to learn about PS LTE interoperability
- Opportunity to begin climbing technical learning curve.
- PS have and will continue to gain significant insights through RFP processes, a powerful method for developing detailed understanding of the contracting and business challenges.

# Potential Lessons Learned by Deploying "FirstNet Phase One," cont'd

- Development of applications, applications stores, standards for applications, creating well-behaved applications, frugal with network bandwidth
- Development of processes and requirements for security and network management, provisioning, priority tweaking, single sign-on
- Enabling cultural changes in the responder community which are engendered by the deployment and use of the network and applications
- Creating opportunity to initiate changes necessary to fully integrate PS BB services into day-to-day PS operations

# THANK YOU!